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ABSTRACT

The classroom practices of 20 teachers were studied during the field test of course 1 of Contemporary Mathematics in Context (CPMP), the high school mathematics curriculum developed by the Core-Plus Mathematics Project. In each year of the CPMP curriculum, mathematics is developed along the interwoven strands of algebra and functions, geometry and trigonometry, statistics and probability, and discrete mathematics. Ten of the teachers were in the top quartile of field test teachers and the other 10 in the bottom quartile with respect to their students' growth in mathematics achievement over the 1-year course. The goal was to provide a description of the classroom practices and concerns of teachers whose students achieve at the highest levels using the practices and concerns of teachers of lower achieving students as a contrast. At the end of the school year, teachers completed a teacher concern survey. One the whole, teachers of first quartile students (first quartile teachers) perceived themselves as better informed about the CPMP curriculum and its use at their school. First quartile teachers expressed less concern about their ability to implement the CPMP curriculum and were less concerned about the impact on their students of using CPMP. These and other findings suggest that a teacher whose behavior is positively associated with growth in student achievement would have strong preparation in reform curriculum and teaching before teaching his or her first CPMP class or would have completed a workshop to prepare for the curriculum. The teacher would use the various parts of the CPMP curriculum in ways that align well with the developers' expectations and would not be likely to supplement the curriculum materials. (Contains 34 references.) (SLD)

TEACHER VARIABLES THAT RELATE TO STUDENT ACHIEVEMENT IN A STANDARDS-ORIENTED CURRICULUM

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Teacher Variables that Relate to Student Achievement in a Standards-Oriented Curriculum

In response to calls for mathematics curriculum reform (National Council of Teachers of Mathematics, 1989, 1991, 2000; National Research Council, 1989, 1990), K-12 curricula have been developed that contain new and re-organized mathematical content. These curricula are also designed to support a teaching approach and classroom environment that emphasize students' engagement in making sense of mathematical ideas largely through problem solving. This pedagogical focus is consistent with recent research on teaching and learning for student understanding (e.g., Bransford, Brown & Cocking, 1999; Cobb, Wood & Yackel, 1993; Stigler & Hiebert, 1999; Fennema & Romberg, 1999). Some evaluation and research evidence is emerging that suggests a positive impact of at least some of these curricula on student learning (Senk & Thompson, In press).

Encouraging as the above studies are, other research shows that teachers differ widely in how they implement potentially rich sense-making tasks in their classrooms resulting in an associated difference in levels of student engagement (Henningsen & Stein, 1997). Similarly, classrooms in which the same Standards-oriented curriculum and teaching practices are purportedly used may be quite different from one another (Lambdin & Preston, 1995; Spillane & Zeuli, 1999). Presently, then, research suggests that Standards-oriented curricula and teaching practices may lead to improved student learning, yet their implementation can vary greatly from one classroom and teacher to another. What is needed is research concerning the teaching behaviors and curriculum implementation strategies that are most strongly associated with student learning.

As Saxe, Gearhart & Seltzer (1999) point out, "We have yet to develop ... a strong corpus of studies that examine relations between student learning and the extent to which pedagogical approaches are aligned with reform frameworks" (p. 2). It is also interesting to note that except for a few curriculum evaluation studies (see Senk & Thompson, In press), nearly all of the research related to these curricula and teaching approaches has been conducted at the elementary or middle

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school levels. There is a pressing need for research on curriculum implementation and teaching in high school classrooms, and the study reported here is a start.

We examine the classroom practices of 20 teachers during the field test of Course 1 of *Contemporary Mathematics in Context* (Coxford, Fey, Hirsch, Schoen, Burrill, Hart & Watkins, 1998), the high school curriculum developed by the Core-Plus Mathematics Project. (This curriculum will be referred to as CPMP or the CPMP curriculum.) Ten of these teachers comprise the top quartile of field test teachers and the other ten the bottom quartile with respect to their students' growth in mathematical achievement over the one-year course. Descriptive data gathered by classroom observers, these observer's holistic rating of the alignment of the instructional practice and classroom climate with CPMP's teaching for understanding model, self-perceptions of practice by the teachers, and concerns of the teachers about the new curriculum are the primary data sources. The goal is to provide a description of the classroom practices and concerns of teachers whose students achieve at the highest levels when teaching CPMP Course 1 using practices and concerns of teachers in the fourth quartile for comparison and contrast.

BACKGROUND

Organization and Content of the Curriculum

In each year of the CPMP curriculum, mathematics is developed along four interwoven strands: algebra and functions, geometry and trigonometry, statistics and probability, and discrete mathematics. These strands are connected within units by common topics such as symmetry, functions, matrices, and data analysis and curve-fitting. The strands also are connected across units by mathematical habits of mind such as visual thinking, recursive thinking, searching for and describing patterns, making and checking conjectures, reasoning with multiple representations, inventing mathematics, and providing convincing arguments. The strands are unified further by fundamental themes of data, representation, shape, and change. The choice of curriculum organization was influenced by the importance of connections among related concepts and procedures in developing deep understanding of mathematics (Skemp, 1987). This curriculum organization serves to break down the artificial compartmentalization of traditional "layer cake" curricula in this country and addresses weaknesses identified in the recent TIMSS findings (Schmidt, 1998). In addition, developing mathematics each year along multiple strands also seems to capitalize on the different interests and talents of students and helps to develop diverse mathematical insights (Hirsch & Coxford, 1997).

Table 1 provides an overview of the scope and sequence of instructional units in CPMP Course 1, the focus of the present study.

Table 1
CPMP Course 1 Units with Content Summaries

Unit 1	**Patterns in Data** Develops student ability to make sense of real-world data through use of graphical displays and summary statistics.
Unit 2	**Patterns of Change** Develops student ability to recognize important patterns of change among variables and to represent those patterns using tables of numerical data, coordinate graphs, verbal descriptions, and symbolic rules.
Unit 3	**Linear Models** Develops student confidence and skill in using linear equations to model and solve problems in situations which exhibit constant (or nearly constant) rate of change or slope.
Unit 4	**Graph Models** Develops student ability to use vertex-edge graphs to represent and analyze real-world situations involving relationships among a finite number of elements, including scheduling, managing conflicts, and finding efficient routes.
Unit 5	**Patterns in Space and Visualization** Develops student visualization skills and an understanding of properties of space-shapes including symmetry, area, and volume.
Unit 6	**Exponential Models** Develops student ability to use exponential functions to model and solve problems in situations which exhibit exponential growth or decay.
Unit 7	**Simulation Models** Develops student confidence and skill in using simulation methods-particularly those involving the use of random numbers-to make sense out of real-world situations involving chance.
Capstone	**Planning a Benefits Carnival**

The instructional model supported by the CPMP curriculum will be discussed in the next section in the context of a more general model of teaching for understanding.

Teaching for Understanding Using the Curriculum

Hiebert, Carpenter, Fennema, Fuson, Wearne, Olivier & Human (1997) argue that classroom instruction is a system of several dimensions. Based on their related research programs, these authors describe the core features of a five-dimensional system for mathematics instruction whose primary goal is to enhance student understanding. First, classroom tasks should make mathematics problematic, connect with where students are, and leave behind something of mathematical value. Second, the teacher's role is to select tasks with goals in mind, share essential information with students, and establish a classroom culture that allows students to struggle with and attempt to make sense of the mathematics. Third, in the social culture of the classroom, ideas are valued, students choose and share their methods, mistakes are learning sites for everyone, and the authority for correctness resides in mathematical argument rather than in the teacher or answer key. Fourth, each user (students and teacher) must construct meaning for intellectual and physical tools that support learning. These tools must be used purposefully to record, communicate and think on the road to solving problems. Fifth, equity and accessibility are also core features of the classroom culture as evidenced by tasks that are accessible to all students and by the fact that every student contributes and is heard. The teaching for understanding model of Hiebert et al. is essentially the same as what some researchers call "reform teaching" (Saxe,et al., 1999; Klein, Hamilton, McCaffrey, Stecher, Robyn, & Burroughs, 2000).

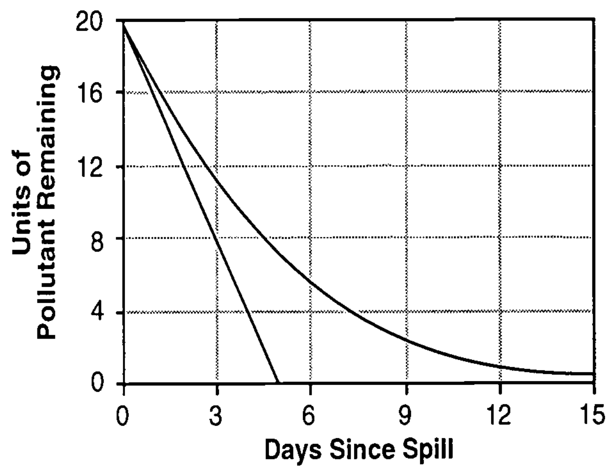
A useful distinction for describing the CPMP version of teaching for understanding is that made by Kilpatrick and Silver (2000). They label as the *contingent* teaching for understanding model the approach exemplified by the NCTM *Professional Standards for Teaching Mathematics* in which the path that teaching follows emerges during the lesson. In contrast, *anticipant* teaching for understanding model is suggested by studies of teaching in some Asian countries. Anticipant teaching follows a path carefully worked out in advance, and every lesson has a clear point to be reached. The CPMP teaching model can be characterized as an anticipant teaching for understanding model in which the instructional path has been worked out in advance by the curriculum developers. Of course, the sequences of questions in CPMP investigations are designed to promote student exploration and sense-making, but they also help to channel the students more or less flexibly toward the mathematical goals. With that clarification, Hiebert et al.'s description of the teacher's role, classroom climate and equity applies also to CPMP. More details concerning CPMP's design and instructional features follow.

An important principle that guided the design of the CPMP curriculum is the belief that mathematics is a vibrant and broadly useful subject that should be explored and understood as an active science of patterns (Steen, 1990). As a consequence, CPMP students explore patterns in gender distribution of juries and multi-child families as an introduction to the concepts and techniques of probability and statistics. They conduct experiments that simulate bungee jumping and analyze patterns in the relation between jumper weight and bungee cord stretch as a prelude to study of algebraic expressions and equations. They study patterns in decorative designs and computer graphic images and then the related geometric ideas of symmetry, congruence, and transformations. Analysis of patterns in road and communication networks leads to important concepts in graph theory that are widely used in computer and management sciences.

Consistent with the view of mathematics as a science of patterns, another underlying principle is that exploration and experimentation necessarily precede and complement theory. CPMP lessons focus on several interrelated mathematical concepts and often span four or five days. Each lesson is introduced as an activity in which the entire class is asked to think about a context such as that in Figure 1 (Coxford et al, 1997), which is used to launch the second lesson of the *Exponential Models* unit in Course 1. In this case, the context is an experiment that simulates pollution of a lake by some poison and the following clean-up efforts. The launch was intended to set the stage by generating discussion and thought about the main ideas of the lesson. It also helps the teacher connect the situation to students' background knowledge.

Think About This Situation

One of the problems of our complex modern society is the risk of chemical or sewage spills that can pollute rivers and lakes. Correction requires action of natural or human cleanup processes, but both take time. The graphs below show two possible outcomes of a pollution cleanup effort following an oil spill.



(a). What pattern of change in pollution level is shown by each graph?

(b). Which graph shows the pattern of change that you would expect from a pollution cleanup effort? Test your idea by running the pollution clean-up experiment several times and plotting the (*time, pollutant remaining*)

(c). What sort of equations relating pollution P and time t would you expect to match your plot of data? Test your idea using a graphing calculator or computer.

Figure 1. Launching the Study of Exponential Decay (*Exponential Models* Unit, Course 1)

Once launched, a lesson usually involves students working together collaboratively in small groups or pairs as they investigate more focused problems and questions related to the launching situation. It is intended that students will at least begin to develop and understand the lesson's important ideas through these investigations. Investigations are always accompanied by opportunities for students to analyze and abstract underlying mathematical structures that can be applied in other contexts. These structures, in turn, often are the subject of further investigations.

Investigative work is followed by a class discussion, usually teacher moderated, in which students share mathematical ideas developed by their groups and together construct a common understanding of important mathematical concepts, methods, and approaches. Sharing and agreeing as a class on the mathematical ideas groups are developing is promoted by Checkpoints in the instructional materials. The sample Checkpoint in Figure 2 (Coxford et al, 1997) is the third of three Checkpoints in the second lesson of *Exponential Models*.

√ Checkpoint

In this lesson, you have seen that patterns of exponential change can be modeled by equations of the form $y = a(b^x)$.

(a). What equation relates *NOW* and *NEXT* *y* values of this model?

(b). What does the value of *a* tell you about the situation being modeled? About the tables and graphs of (x, y) values?

(c). What does the value of *b* tell you about the situation being modeled? About the tables and graphs of (x, y) values?

(d). How is the information provided by values of *a* and *b* in exponential equations like $y = a(b^x)$ similar to, and different from, that provided by *a* and *b* in linear equations like $y = a + bx$?

Be prepared to compare your responses with those from other groups.

Figure 2. Summarizing and Formalizing Mathematical Discoveries

Each Checkpoint is followed by a related On Your Own assessment task which is intended for individual students, mainly as an assessment of their understanding of the main ideas of the previous investigation. Each lesson is accompanied by a set of additional tasks to engage students in modeling with (M) , organizing (O), reflecting on (R), and extending (E) their mathematical understanding developed through the investigations. These MORE tasks are intended primarily for individual work outside of class.

Assessment is embedded in the CPMP curriculum materials and is an integral part of instruction. The instructional materials support continuous assessment of group and individual progress through observing and listening to students during the exploring and summarizing phases of instruction. In addition, there are individual assessments at the end of each lesson which measure understanding of mathematical concepts, methods, and skills, and there are similar individual and group assessments at unit, semester, and course end. Assessments include one- or two-day take-home tasks and one- to two-week group projects that require a written and/or oral in-class report. CPMP developers recommend that teachers assign at least one or two projects per year so students apply mathematics in a larger context and prepare written or oral reports of their work.

The CPMP curriculum incorporates graphing calculators and project-developed downloadable calculator software as tools for learning and doing mathematics. The use of graphing calculators permits the curriculum to emphasize multiple representations (numerical, graphical, and symbolic) and to focus on goals in which mathematical thinking is central. Their use in the curriculum promotes versatile ways of dealing with realistic situations and for some students reduces the manipulative skill filter which would have prevented them from studying significant mathematics.

One additional unique feature of each of the CPMP courses is the inclusion of a thematic capstone as seen in Table 1. These project-oriented capstones provide individuals and groups with rich mathematical problems that, for solution, require the use of mathematics from each of the four strands studied during the year. This is a unique opportunity for students to review and consolidate their learning and demonstrate their mathematical growth over the year. Throughout, the teacher's role is intended to align with the teaching for understanding model described earlier. For more detail on CPMP pedagogical perspectives and instructional model embedded in the curriculum, see Hirsch, Coxford, Fey, & Schoen (1995) and Schoen, Bean, & Ziebarth (1996).

Related Research

In design, the present study is similar to the process-product, sometimes called effective teaching, studies conducted mainly in the 1970s and 1980s. Like the present study, process-product studies sought to describe teacher behaviors that correlate positively with growth in student achievement on standardized tests (cf. reviews by Rosenshine & Furst, 1973; Brophy & Good, 1986). Most such studies were conducted in classrooms as the researchers found them. As a result, in nearly every case the curriculum and classroom organization were designed to support the teacher in direct instruction. It is not surprising then that virtually all of the "effective" teacher variables from this body of research involve behaviors associated with teacher-focused direct instruction, such as clarity of presentation, teacher wait time, teacher feedback, teacher's use of praise or criticism, teacher's questioning strategies, and so on. If a teacher uses direct instruction in a traditionally organized classroom and a textbook that supports such instruction, then the behaviors consistently identified by these researchers are likely to be associated with students' higher standardized test scores. This body of research, however, says nothing about effective teaching behaviors associated with student achievement in a very different system of classroom instruction like that used in CPMP classrooms.

As for the CPMP curriculum and teaching model specifically, evidence mainly from the national field test suggests that students in the CPMP curriculum score better on measures of conceptual understanding, applications, and problem solving than students at comparable points in the traditional college preparatory curriculum. Comparisons on measures of paper-pencil algebraic skill yield mixed results (Schoen & Hirsch, In press). These comparative studies were conducted across all levels of implementation of the CPMP and traditional curricula. Assuming though that teaching in CPMP classrooms was better aligned with the teaching for understanding model than teaching in traditional comparison classes was, these achievement results fit an emerging pattern for research based on teaching aligned with the reform or teaching for understanding model.

In addition to the large-scale studies described in the previous paragraphs, some researchers have studied individual teachers in CPMP classrooms. Lloyd & Wilson (1998) investigated the content conceptions of an experienced high school mathematics teacher and linked those conceptions to their role in the teacher's first implementation of the CPMP curriculum. The teacher communicated deep and integrated conceptions of functions, dominated by graphical representations and covariation notions. The researchers describe in detail how this teacher reconciled his own conceptions of functions with the CPMP "patterns of change" approach. In a related report, Lloyd & Wilson (1997) describe two high school teachers interpretations of and classroom experience with the CPMP curriculum. This study focused on the teachers' conceptions of cooperative explorations of mathematical situations. Interestingly, one teacher saw this aspect of CPMP as a challenging vision of instructional practices, while the other saw the CPMP investigations as being too orchestrated by sequences of questions in the materials. She preferred an even more open-ended approach. This difference in the perspectives of teachers is similar to differences that Lambdin & Preston (1995) found among middle school teachers when they first used a reform curriculum.

Studies like the above that compare student achievement and those that describe teachers as they use reform curricula and teaching approaches are important. As we noted earlier, however, what is needed is a link between student achievement and teaching behaviors. Some recent research has begun to study the teaching behaviors and reform curriculum implementation strategies that are most strongly associated with student learning. To evaluate the extent to which classroom practices in their middle school study were aligned with reform principles, Saxe and his colleagues (1999) developed rating scales and applied them both to videotape and field note records of lessons. Similar to the achievement pattern in the comparative studies in CPMP classrooms, they found that classroom practice aligned with reform principles was related to student achievement in problem solving but not in computation. They also found that the relation differed for students who began instruction with different levels of prior knowledge as measured by a pretest.

In the 'mosaic' study of systemic initiatives (SI) in mathematics and science, Klein, et al. (2000) studied the relationship between instructional practices and student achievement in each SI site. Instructional practices in this study of third- through eighth-grade sites were measured by a teacher questionnaire that asked teachers about the frequency with which they used various types of reform and traditional instructional practices. The authors found that the relationship between student achievement and the use of reform instructional practices tended to be positive, but small in comparison to student background characteristics such as socio-economic status and ethnicity.

In a study conducted in eighth- and ninth-grade algebra classes of 94 teachers, Mayer (1998) found that students whose teachers spent more time using the NCTM teaching approach had higher growth rates as measured by three standardized algebra assessments than students whose teachers spent less time using the approach. Written surveys were used to measure instructional practices. Mayer notes that "If, as other studies indicate, the new standards help students on more novel tests, the finding that students benefit or at least are not hurt on traditional tests strengthens the case for implementing the NCTM reforms." In a similar vein, as they looked over this body of studies, Bransford and his colleagues (1999) observed that "In some cases there is evidence that teaching for understanding can increase scores on standardized measures; in other cases, scores on standardized tests are unaffected, but the students show sizable advantages on assessments that are sensitive to their comprehension and understanding rather than reflecting sheer memorization" (p. 177).

The present study has similarities and differences as compared to those cited in this section As in the cited studies, we are interested in the association between student achievement and teaching practices. We use a design similar to the process-product studies, that is, we contrast the teaching practices of teachers whose students were at the two ends of the distribution of growth in student achievement. Of course, this is just one way to look at an association; Saxe et al. (1999) and Klein et al. (2000) used regression methods. To measure teaching practice, like Saxe et al. we draw on ratings from class observations. Like Mayer (1998) and Klein et al., we also use a written survey in which teachers report their use of various strategies and class organizations. Finally, unlike Saxe et al., Klein et al., and the vast majority of the process-product studies, our study is carried out in high school classrooms, and our teachers are all using a new and complete curriculum designed to support teaching for understanding.

METHOD

Purpose

The purpose of this article is to report a study of teaching behaviors and concerns of CPMP teachers that correlate positively with growth in their students' mathematical achievement. The method is to contrast the levels of these behaviors and concerns for two groups of ten teachers whose students' growth in achievement were at the extremes of the distribution of achievement gain. Course 1 was chosen, since at this stage students have only experienced one CPMP teacher. In subsequent courses, important relationships may be confounded by the students' experience with other teachers in previous CPMP courses. Dependent variables of interest were teacher behavior and teacher concern variables as they pertain to the implementation of CPMP Course 1.

Procedures and Sample

During the one-year field test of CPMP Course 1, students completed a form of *Ability to Do Quantitative Thinking*, the mathematics subtest of the *Iowa Test of Educational Develpment* (ITED-Q) in early September and an equivalent form at the end of the school year. At least one and as many as three CPMP classes of many teachers were observed sometime during the school year by a CPMP evaluator using a structured observation protocol. Teachers completed a written survey at mid-year that asked them to describe details concerning their implementation of CPMP Course 1. Finally, teachers completed a written Teacher Concern Survey at the end of the school year. Table 2

Table 2
Instruments Used in Data-Gathering With Their Target and Time of Administration

Instrument	**Target**	**Time of Administration**
ITED-Q (Form K, Level 15)	Students	Beginning of Year
Class Observations	Teachers & Students	During the year
Implementation Survey	Teachers	Mid-year
Concerns Survey	Teachers	End of year
ITED-Q (Form L, Level 15)	Students	End of year

lists the instruments that were used with their targets and time of administration, and these instruments are later described in more detail.

The set of data from all instruments in Table 2 was virtually complete for 40 teachers in 27 schools and their students. For these 40 teachers, the difference between their students' mean standard scores on the ITED-Q pretest and the same students' mean standard scores on the ITED-Q posttest was computed. This difference served as an indicator of the growth in achievement of the students of each teacher during Course 1. Two groups of teachers were then identified, (1) the first quartile, that is, the ten teachers with the greatest growth in student achievement and (2) the fourth quartile, that is, the ten teachers with the least growth in student achievement. These 20 teachers and their 803 students from 17 schools are the sample for this study.

The gender, school type, and growth in student achievement for the top and bottom quartiles are summarized in Table 3. More female teachers are in the top group, and more teachers from urban schools are in the fourth quartile. Students of first-quartile teachers started at a higher pretest level than those of fourth-quartile teachers, a phenomenon that is related to the larger number of urban schools in the fourth quartile. Although neither the gender nor the school type differences are significant at the 0.05 level using a chi-square test, these differences will be examined more closely relative to the teacher behaviors and other variables that emerge as correlates of achievement gain.

Table 3
Gender, School Type, and Students' ITED-Q Achievement Growth for Teachers in the First and Fourth Quartiles

	Gender		**School Type**			**Pretest**	**Post - Pre Growth**		
Teacher Group	**M**	**F**	**Urban**	**Subur**	**Rural**	**Mean**	**Mean**	**Min**	**Max**
First Quartile	2	8	2	4	4	253.1	20.1	14	25
Fourth Quartile	5	5	5	3	2	242.5	1.1	-3	4

Instruments

Iowa Test of Educational Development The ITED is a nationally standardized battery of high school tests developed by the Iowa Testing Programs, the same group that writes the widely used elementary school level *Iowa Tests of Basic Skills* (ITBS). The ITED-Q is a 40-item multiple-choice test with the primary objective of measuring students' ability to employ appropriate mathematical reasoning in situations requiring the interpretation of numerical data and charts or graphs that represent information related to business, social and political issues, medicine, and science. The ITED-Q correlates highly with other well-known measures of mathematical achievement. According to research conducted by the test's developers, correlation of the ITED-Q when given in grade nine with the ITBS Mathematics total score in grade eight is .81; with students' final cumulative high school grade point average in mathematics courses is .59; with the ACT Mathematics test is .84; and with the SAT Mathematics test is .82. The ACT and SAT are usually completed in eleventh or twelfth grade.

Class Observation Form Three observers, a professor and two doctoral students in mathematics education, trained and practiced together to make consistent classroom observations and ratings. All observers had at least four years of secondary school mathematics teaching experience. The data gathered by individual observers was spread across the distribution of teachers based on their students' growth in achievement, so any effect due to differences in observers did not affect the results in this study.

In addition to recording the time frame of class activities and transitions, observers commented on the categories of activities that are specifically related to teaching for understanding.

- The mathematical content of the teacher's discussion was accurate.
- The teacher used open-ended questioning.
- Students served as monitors of their own work.
- Students were given enough time to learn from the investigations.
- Class organizations (i.e., whole class presentation or discussion, pair or small group work and individual work) matched expectations for each part of a lesson.
- Pairs or small groups of students actually worked collaboratively.
- Students appeared to understand the big mathematical ideas of the lesson.
- Graphing calculators were available and used appropriately.

As soon after the class as convenient, the observer made a holistic rating (excellent, good, fair, or poor) of the extent to which activities in these categories were observed. The rating was based on the observer's general impression of how well the teaching and classroom climate matched the entire set of criteria. The higher the rating, the better the observed class was aligned with the teaching for understanding model.

Mid-Year Teacher Survey The written teacher survey sought checklist and open-ended information concerning teacher perceptions of their own classrooms in several categories. Overall estimates were requested of percent of class time spent in various class organizations. Information was sought concerning background characteristics of the class, use of particular CPMP curriculum features, homework practices, assessment and grading policies, and amount of out-of-class preparation. The extent and nature of supplementing and revising the CPMP curriculum materials and assessments was another focus area.

Teacher Concern Survey This survey is a 35-item likert scale that measures teachers' concerns about teaching a new curriculum. The survey is an adaptation of the Concerns-Based

Dimension 1: Self

Awareness - What is CPMP trying to do?

Information - What materials and other help are available to me when I use CPMP?

Personal - How will using CPMP affect the demands of my job and my status?

Dimension 2: Task

Management - Will I have the time, energy, and talent to do a good job?

Dimension 3: Impact

Consequences - How will CPMP affect student outcomes?

Collaboration - How can I work with others to implement CPMP?

Re-focusing - How can I improve on what CPMP offers?

Figure 3. Dimensions and Subscales of the *Teacher Concern Survey*

Adoption Model (Hall, 1979) that has three main subscales, Concerns about Self, Concerns about Task, and Concerns about Impact, as shown in Figure 3.

Exploratory Analysis

Our method of contrasting teacher behavior variables of teachers in the first and fourth quartiles is clearly one way to describe the association between teachers' behaviors/concerns and the growth in achievement of their students. Prior to developing the descriptions that follow, we computed correlation coefficients in the full set of 40 teachers between mean growth in student achievement and the teacher behavior variables generated from the class observation and survey data. For the most part, the variables that we describe in our "Results" section for the two quartiles were moderately to highly correlated with mean student growth in achievement. These teacher behavior variables include the observers' ratings of teachers' classes ($r = .30$) and teachers' estimates of the percent of class time they spent on teacher-led presentations ($r = -.53$) and on work in small groups or pairs ($r = .41$). Whether a teacher supplemented CPMP materials ($r = -.26$) at all, especially with review or skill worksheets ($r = -.23$), and whether they supplemented the CPMP assessments ($r = -.38$) were also correlated with achievement growth, as were use of take-home assessment questions ($r = .33$), oral reports ($r = .21$), and assessment projects ($r = .17$). Finally, the number of "Extending" exercises assigned by a teacher was positively correlated ($r = .47$) with students' achievement growth.

In the following descriptions, we ignore teachers in the second and third quartiles in the distribution of mean growth in student achievement. However, the correlation coefficients suggest that levels of the above variables generally increase or decrease with mean growth in student achievement depending on whether the coefficient is, respectively positive or negative. The middle two quartiles can be expected to differ more moderately on these variables but in the same direction as in the two extreme quartiles described next.

RESULTS

Professional Development and Prior Experience Teaching CPMP

The CPMP staff delivered a two-week summer workshop for field-test teachers in the summer before the Course 1 field test. The workshop gave teacher participants an opportunity to deepen their understanding of the content of the course and the intentions of the curriculum developers concerning its implementation. The interaction among the participants was especially valuable, as was the future networking that began during the summer workshop. Most workshop time was spent by teacher participants, under the guidance of the workshop leaders, working through the CPMP units as if they were students and then reflecting on how they would teach their own students what they had just experienced.

Six of the ten teachers in the first quartile attended the Course 1 field-test workshop. See Table 4. Two of the remaining four had attended a similar Course 1 Pilot Test workshop during the previous summer, leaving just two of the ten who were not in a Course 1 workshop prior to teaching Course 1 in the field test. Of those two, one was a graduate student advisee of the CPMP director. This teacher had a great deal of previous course work and experience with CPMP-like content and teaching methods. She also served as an assistant in the Course 1 summer workshop, so her prior preparation was probably even stronger than workshop participation would have provided. The tenth teacher was an experienced teacher leader at the state level. There was little question that she, too, was exceptionally well-prepared to teach CPMP Course 1.

Table 4
Number of Teachers by Quartile at Each Level of Preparation for Teaching CPMP Course 1

Quartile	Co. 1 FT Workshop	Co. 1 PT Workshop	Other Prof. Preparation	Taught Pilot Course 1
First	6	2	2	3
Fourth	1	2	0	6

On the other hand, only one of the ten fourth-quartile teachers completed the Course 1 field-test workshop. Two others completed the earlier Course 1 workshop for the pilot study. Seven of the ten teachers in the fourth quartile had no special preparation prior to teaching the course. In spite of their relative lack of CPMP-specific professional development, the teachers in the fourth quartile had more previous experience teaching CPMP Course 1. Six of the ten fourth-quartile teachers compared to just three teachers in the first quartile taught CPMP Course 1 in the pilot test during the previous school year.

Class Characteristics

Average class size, probably slightly underestimated from average numbers of "students present" when classes were observed, did not differ significantly by quartile (21 in the first quartile versus 19 in the fourth). Teachers' classifications of the make-up of their CPMP Course 1 students according to their likely membership in previous mathematics achievement groups are summarized by quartile in Table 5. The most common descriptor in both quartiles is "wide range of abilities but excluding the top students." Overall, there is little difference between the make-up of classes in the two quartile groups.

Table 5
Frequncies of Teacher-Described Student Characteristics of Their CPMP Classes by Quartile

Class Make-up	**Quartile 1**	**Quartile 4**
No grouping—whole range of ninth-grade students	2	3
Wide range of abilities but excluding the top students	6	6
More or less the typical Algebra group	1	0
More or less the typical general mathematics group	1	1

The mean length of a class period did not differ significantly by quartile (56.1 minutes in the first quartile compared to 54.1 in the fourth). Across all twenty teachers, class length ranged from 41 to 90 minutes, and the median length was 55 minutes. One teacher in each quartile was on a modified block schedule with longer periods on some days, and no class on others. The amount of time that teachers reported spending on class preparation, grading and helping students did not differ significantly by quartile in any category.

Class Observer Ratings

Two classes of each of the ten teachers in the fourth quartile and six of the ten in the first quartile were observed. Just one class of the other four fourth-quartile teachers was observed. The observations were arranged in advance with the teachers and occurred at various times from October to May during the school year. Such a small number of observations are not representative for a particular teacher, but consistent patterns begin to emerge across the ten teachers in each quartile. One indicator of how well a teacher was following the teaching for understanding model was a holistic observer rating (excellent, good, fair, and poor) based on the categories described in the *Instruments* section.

Numbers of teachers by quartile and rating category are given in Table 6. Overall, teachers in the first quartile were rated higher by observers than those in the fourth quartile. Fifteen of the twenty classes of fourth-quartile teachers were rated as either "fair" or "poor." Classes of just two teachers in the fourth quartile were rated as "excellent," and they both received that rating in two classes. By contrast, no classes of teachers in the first quartile were rated as "poor" and five were rated as "fair." Four teachers in the first quartile received at least one "excellent" rating, and six received at least one "good."

Table 6
Numbers by Quartile of Observations in Each Rating Category and of Teachers Who Received at Least One Rating in Each Category

	First Quartile		Fourth Quartile	
	Number of Observations	Number of Teachers	Number of Observations	Number of Teachers
Excellent	5	4	4	2
Good	6	6	1	1
Fair	5	4	7	5
Poor	0	0	8	5

The class observation ratings suggest that teachers whose students gain most in achievement tend to teach for understanding. Those with weaker student gains vary more from the teaching for understanding model. The two teachers in the fourth quartile whose classes were rated as excellent are exceptions, at least as measured by observer ratings. We will return to them after presenting further implementation data. The results in the following three sections are self-reported by the teachers on a written mid-year survey.

Classroom Teaching Practices

Teachers were asked to estimate the percent of class time they spent on each of the main parts of the lessons (i.e., launch, investigation, checkpoint, on your own and MORE or homework problems). They were also asked to estimate the percent of time their classes were in each of four organizations (i.e., whole-class presentation, whole-class discussion, small groups or pairs, and individual work) during each of the lesson parts. Table 7 gives the results by quartile.

Table 7
Percent of Time Spent in Each Class Organization by Lesson Feature and Quartile

	Launch		Investigation		Checkpoint		On Yr. Own		MOREs	
	Q1	Q4	Q1	Q4	Q1	Q4	Q1	Q4	Q1	Q4
% class time	6.7	9.2	64.2	50.7	12.3	10.3	5.4	7.6	11.4	22.2
Whole-Class Presentation	22.2	41.7	16.8	30.0	15.0	21.7	0.8	12.5	1.4	8.7
Whole-Class Discussion	66.5	54.8	2.8	15.6	27.9	36.9	12.9	15.5	11.2	5.6
Small Groups or Pairs	9.5	1.5	80.4	54.3	56.4	40.6	25.7	17.4	32.5	33.5
Individual	1.9	1.9	0.0	0.0	0.7	0.8	60.6	54.6	54.9	52.1

Teachers in the first quartile compared to those in the fourth quartile estimated that they spent more class time on the investigations (64.2% compared to 50.7%) and less time on MORE exercises (11.4% compared to 22.2%). As for the launch, teachers in the first quartile estimated that they used whole-class presentation less than those in the fourth quartile while using more discussion in a whole group and in small groups or pairs. During investigations, students of first-quartile teachers spent more time working in small groups or pairs when compared to students of fourth-quartile teachers. The fourth-quartile teachers spent much more time during investigations using lecture/discussion as evidenced by the combined mean of 45.6% of class time in whole-class presentation and discussions compared to 19.6% for first-quartile teachers.

The "Checkpoint" is an opportunity for teacher and students to consider and assess what was learned in the previous investigation by different student groups. No particular class organization was intended, and the data suggest that teachers in the fourth quartile used whole-class presentation and discussion more than small group discussion with the reverse being true of teachers in the first quartile. The "On Your Own" was intended as a curriculum-embedded, individual assessment. Field-test interviews and other teacher feedback indicate that most teachers assigned the "On Your Own" problems as homework, so the data in Table 7 mainly shows how the class was organized when these problems were gone over after they had been tried by individual students at home. Again, teachers in the fourth quartile used whole-class presentations more and small groups less than teachers in the first quartile. As noted above, teachers in the fourth quartile spent more class time on the MORE exercises than did teachers in the first quartile. As in all other lesson parts, teachers in the fourth quartile used more whole-class presentation than teachers in the first quartile when the class was working on these problems.

The patterns of class organization described above are based on teachers' self-reported estimates at mid-year, but they are generally supported by class observation data which shows a higher mean percent of small group work (52% versus 45%) and less individual work (1% versus 8%) for teachers in the first quartile. Class observers also noted seeing somewhat less time spent on non-academic activities—such as classroom management, taking attendance, and making or listening to non-academic announcements—in classes of first-quartile teachers (0.8% versus 2.1%).

Homework Practices

The CPMP developers recommend assigning one or two of each type of MORE problem per lesson. Some particular problems are recommended, but most are left for teacher or student choice. All teachers, with the exception of one in the first quartile, indicated on their surveys that they "follow CPMP's recommendations for the most part." Nevertheless, there are some interesting differences by quartile in the numbers of each type of MORE problem that are assigned to be done in class or at home. See Table 8.

Table 8
Mean Number Per Lesson of Each Type of MORE Exercise Assigned for In-class and Homework by Quartile

Problem Type	**First Quartile**			**Fourth Quartile**		
	Homework	**In-Class**	**Total**	**Homework**	**In-Class**	**Total**
Modeling	1.5	1.1	2.6	1.2	1.4	2.6
Organizing	1.7	1.1	2.8	1.2	1.2	2.4
Reflecting	1.4	1.1	2.5	1.2	0.8	2.0
Extending	1.2	0.8	2.0	0.8	0.0	0.8

Fourth-quartile teachers made more use of Modeling and Organizing problems in class, which probably explains the greater class time spent on MORE problems that was noted in Table 7. On average, first-quartile teachers assigned more homework, and they assigned more Extending problems for either outside or in class. In fact, one teacher in the fourth quartile assigned no problems to be done outside of class. Consistent with these differences by quartile, first-quartile teachers counted homework to be worth a somewhat greater percent when determining students' grades than teachers in the fourth quartile did as reported in the next section.

Assessment and Grading

The CPMP curriculum supports a variety of assessment methods. Some of them and their level of use by teachers in each quartile are given in Table 9. Teachers in the first quartile made more use of these methods than teachers in the first quartile did. Largest differences were in the use of oral reports and journals. Nine teachers in the first quartile and just four in the fourth quartile used oral reports. Some teachers in both quartiles used journals, but first-quartile teachers did not count them in grading students while fourth-quartile teachers did.

Table 9
Numbers of Teachers in Each Quartile Who Grade, Use But Not Grade, or Not Use Each Assessment Method

	First Quartile			**Fourth Quartile**		
Method	**Grade**	**Not Gr**	**Not Use**	**Grade**	**Not Gr**	**Not Use**
Group Observations	7	3	0	9	1	0
Written Reports	7	0	3	5	1	4
Oral Reports	4	5	1	3	1	6
Journals	1	6	3	5	0	5
Interviews	1	4	5	1	1	8
Take-home Exams	8	2	0	7	3	0
Portfolios	4	1	5	1	1	8

The CPMP curriculum provides assessment materials including lesson quizzes, in-class unit exams, take-home exams, longer-term projects, and assessment tasks for semester exams. The reported level of use of each of these assessment features is given in Table 10. Overall, first-quartile teachers made more regular use of the CPMP assessment materials than fourth-quartile teachers did. The largest difference was in the use of CPMP projects by eight teachers in the first quartile, while seven of those in the fourth quartile never used these projects.

Table 10
Number of Teachers in Each Quartile and Their Level of Use of CPMP Assessment Materials

	First Quartile				Fourth Quartile			
Material	**Always**	**Freq**	**Rarely**	**Never**	**Always**	**Freq**	**Rarely**	**Never**
Quizzes	3	4	3	0	3	5	0	2
I-C Unit Ex.	4	3	2	1	3	1	3	3
T-H Unit Ex	1	2	5	2	0	1	5	4
Projects	0	1	7	2	0	2	1	7
I-C Sem Ex	9	0	0	1	7	2	0	1

An important indicator of expectations in a classroom is the list of factors and weights that the teacher uses to determine students' grades. A summary of grading factors and weights used by CPMP teachers in each quartile is given in Table 11. There are few major differences by quartile,

Table 11
Mean Percent Weights and Ranges of Various Factors Used by Teachers in Each Quartile for Determining Students' Grades

	First Quartile		Fourth Quartile		Combined Group	
Factor	**Mean**	**Range**	**Mean**	**Range**	**Mean**	**Range**
In-class exams	27.5	15-50	27.4	11-60	27.5	11-60
Quizzes	23.0	10-35	16.1	5-25	19.6	5-35
Homework	19.2	5-30	16.1	0-30	17.7	0-30
Group work	11.3	0-25	17.3	5-33	14.3	0-33
Class part., att/eff, attend.	7.6	0-21	9.3	0-35	8.5	0-35
Notebooks, journals	6.5	0-20	10.2	0-50	8.4	0-50
Written/oral reports	5.0	0-20	2.0	0-10	3.5	0-20

but some moderate differences are of interest. In particular, first-quartile teachers put more weight on quizzes and reports and less weight on group work, notebooks/journals, and, to a lesser extent, class participation, effort and attendance. The difference in weights for reports is expected from previous results, but the group-work difference may seem surprising since teachers in the first quartile used much more group work. If there is a valid generalization here, it seems to be that first-quartile teachers based grades more on frequent short individual achievement measures and large scale projects (culminating in reports) and less on students' attendance, behavior in class, and personal writing.

Supplementing the CPMP Materials

The above results refer to teachers' use of CPMP instructional and assessment materials, but, of course, some teachers supplemented the CPMP materials in various ways. Four teachers in the first quartile reported doing some supplementing compared to twice that number in the fourth quartile. If they indicated that they supplemented, teachers were asked to check each type of supplementing they did and describe other types that did not appear on the checklist. The numbers of teachers in each quartile who reported using each of the main types of supplementing are given in Table 12.

Table 12
Number of Teachers in Each Quartile Who Supplemented the CPMP Materials and How They Supplemented

Type of Supplementing	**First Quartile**	**Fourth Quartile**
Any Supplementing	4	8
Review Worksheets	1	4
Practice Worksheets	1	2
Discovery Material	2	1
External Test Preparation	1	2
Other	2	3

The first-quartile teachers used a variety of materials to supplement the CPMP curriculum. Adding to the variety seen in the table, one of the teachers in the first quartile in the "Other" category used games for special days such as before holidays, and the second supplemented by occasionally bringing in more physical models. However, teachers in the fourth quartile mainly supplemented with review and practice worksheets. The three fourth-quartile teachers in the "Other" category used, respectively, supplementary lists of vocabulary words, sheets with blank graphs to save students time, and lists of test results from other classes as a data set to explore.

As with the curriculum materials, some teachers constructed their own tests and quizzes or substantially revised those provided in the CPMP curriculum. The number of teachers in each quartile who reported doing so, the total number of times in the semester that they did so, and the types of revisions that were made are given in Table 13. As with the curriculum materials, teachers in the first quartile were more likely to use CPMP assessments as they are. On the other hand, all ten fourth-quartile teachers reported substantially revising or replacing a CPMP assessment at least once during the semester. Revisions that made a test or quiz more structured (i.e., "more direct hints," "less open-ended," and "more format cues") were reported nine times by fourth-quartile teachers and just once by those in the first quartile. Revisions by teachers in the first quartile were most likely to be combining questions from different CPMP test or quiz forms.

Table 13
Number of Teachers in Each Quartile Who Substantially Revised or Replaced CPMP Assessments and the Types of Revisions

Type	**First Quartile**	**Fourth Quartile**
Number of Teachers	5	10
Number of Times in the fall semester	16	40
More direct hints	0	2
Less open-ended	0	4
More skill items	1	1
Better align with class coverage	1	4
Similar, combine CPMP questions	3	6
Format cues (e.g., blanks, tables, axes)	1	3
Make shorter	0	1
Make longer	1	3

Teacher Gender and School Setting

The two groups of ten teachers were formed using their students' mean gain in achievement as criterion. However, as Table 3 shows, the distributions of gender and school setting (urban, suburban and rural) differed for the two groups of teachers. An important question for interpreting the above findings is how much of the variability between quartiles can be explained by differences in teacher gender or school setting. If these variables explain much of the group differences, then they interfere with our goal of describing the behaviors of teachers whose students are at the extremes of the distributions in achievement growth.

We address this question by examining whether the between group classroom implementation comparisons are generally consistent within gender and school setting categories. If the pattern of differences between teachers of the same gender in the first quartile and in the fourth quartile is similar to the pattern presented above for all teachers, then gender does not explain these differences. An analogous argument applies for school setting (urban, suburban and rural). This calls for a re-analysis of the results presented above by gender and by school setting.

Space considerations dictate against presenting a complete re-analysis; rather we will consider the impact of gender and school setting for some of the most salient variables. Relative to classroom implementation, some of the most significant and interesting differences by quartile were on use of small groups overall, assigning of extending exercises, supplementing CPMP materials and assessments, and using extended projects for assessment. With few exceptions, quartile differences within gender and school setting categories were in the same direction as the overall quartile differences reported above.

First-quartile teachers reported using more small group or pair work, on average, than fourth-quartile teachers in every subgroup (urban: 42.5% versus 37.0%; suburban: 62.0% versus 38.3%; rural: 56.3% versus 32.5%; female: 56.8% versus 31.0%; male: 55.0% versus 42.0%). First-quartile teachers reported assigning more extending exercises per lesson, on average, than fourth-quartile teachers in suburban schools (1.5 versus 0) and in rural schools (1.0 versus 0.8), but in urban schools the difference was reversed (0.8 versus 1.2). Male teachers in the first quartile reported assigning more extending exercises per lesson than other male teachers in the fourth quartile (1.5 versus 0.3), but for female teachers the difference was reversed (1.1 versus 1.2).

Fewer teachers in the first quartile than in the fourth quartile reported supplementing the CPMP instructional materials in urban schools (0/2 versus 4/5) and in suburban schools (1/5 versus 2/3). In rural schools, all three first-quartile teachers and both fourth-quartile teachers reported supplementing the instructional materials, but two of the three in the former group supplemented with more discovery materials and both teachers in the latter group supplemented with skill worksheets. In every subgroup, proportionally fewer teachers in the first quartile than in the fourth reported supplementing or revising CPMP assessments (urban: 0/2 versus 4/5; suburban: 1/4 versus 1/3; rural: 1/3 versus 2/2; female: 2/8 versus 4/5; male: 0/2 versus 3/5). In every subgroup, proportionally more teachers in the first quartile than in the fourth reported using long-term assessment projects (urban: 2/2 versus 1/5; suburban: 4/5 versus 1/3; rural: 2/3 versus 0/2; female: 6/8 versus 3/5; male: 2/2 versus 0/5).

The class observation ratings given in Table 6 were also analyzed by school setting and teacher gender. The results are given in Table 14. Again the quartile differences within subcategories show a pattern that is consistent with the overall differences by quartile shown in Table 6. As noted earlier, the two male fourth-quartile teachers who were both rated as "excellent" for their two class observations are an exception to the pattern. These teachers will be discussed further in a later section.

Table 14
Numbers of Class Observations Ratings by Quartile in School Setting and Gender Sub-Categories

	School Setting						Teacher Gender			
	Urban		Suburban		Rural		Male		Female	
Rating	Q1	Q4	Q1	Q4	Q1	Q4	Q1	Q4	Q1	Q4
Excellent	0	0	4	2	1	2	2	4	3	0
Good	2	1	2	0	2	0	1	0	5	0
Fair	1	4	3	2	1	1	0	1	5	6
Poor	0	5	0	2	0	1	0	4	0	4

In summary, the numbers are small and the differences even smaller for some of these dependent implementation variables, but there is a clear pattern of agreement between the overall differences by quartile and those in each of the school setting and gender sub-categories. Such a pattern suggests that neither school setting nor gender interact in a significant way with growth in student achievement, the criterion by which the quartile groups were formed. A third potential explanatory variable, the initial difference in students' level of mean pretest achievement, is effectively eliminated as well since it is closely related to school setting and unrelated to growth in student achievement ($r = .04$ between mean pretest score and mean achievement growth). It seems appropriate to conclude that the overall differences are indicative of an association between teacher implementation behaviors and growth in student achievement across school setting, pretest achievement level, and teacher gender.

Teacher Concerns About the New Curriculum

At the end of the school year, each teacher completed a likert-type *Teacher Concern Survey* based on the CBAM model (Hall, 1979). According to the CBAM model, teachers progress through the three dimensions in the order given in Figure 3. Teachers who are novices with a new program like CPMP are likely to have concerns mainly in the Self Dimension. As they gain knowledge and experience, their concerns are likely to move on to the second (Task) and third (Impact) dimensions. Once a teacher's concerns are mainly at higher levels, the lower level concerns are likely to have disappeared.

While the survey statements are descriptive and not necessarily evaluative, there are some clear patterns in the results. On the whole, first-quartile teachers perceived themselves as better informed about the CPMP curriculum and its use at their school, a finding that may be related to the fact that more first-quartile teachers completed CPMP summer workshops prior to teaching Course 1. For example, all of the first-quartile teachers compared to just six of the fourth-quartile teachers indicated that they knew what resources were available to them when using CPMP. Six of the ten first-quartile teachers compared to just two in the fourth quartile indicated that they knew who will make the decisions after CPMP is adopted.

First-quartile teachers expressed less concern about their ability to implement the CPMP curriculum. For example, more first-quartile teachers indicated satisfaction with their ability to manage group work (9 to 6) and assessment (8 to 5) in CPMP. Three teachers, all in the fourth-quartile, indicated concern that CPMP requires too many changes at once, and only one first-quartile teacher compared to five in the fourth quartile expressed concern about the changes required in the teacher's role.

Teachers in the first quartile were also less concerned about the impact on student outcomes of using CPMP. For example, more first-quartile teachers expressed no concern about CPMP's impact on (1) low ability students (6 to 3), (2) students' understanding of mathematical concepts (10 to 7), (3) students' skill at algebraic computation (8 to 3), (4) students' level of excitement about mathematics (10 to 7), and (5) students' level of preparation for college mathematics (8 to 5).

On the other hand, there was little difference by quartile at the higher end of the CBAM model, that is, in the teacher's desire to cooperate with and inform other teachers about CPMP or in the desire to improve upon the materials and approaches made available by CPMP.

Exceptions to the General Pattern

Two classes each of two fourth-quartile teachers were rated as "excellent" by CPMP evaluation staff, a notable exception to the pattern of better ratings for classes of teachers in the first quartile. Both are men, call them Mr. Day and Mr. Knight, whose students showed virtually no growth from pretest to posttest. Mr. Day teaches in a suburban school and Mr. Knight in a rural school. While they were obviously observed on days when their classes appeared to the observer to match the teaching for understanding model very well, a perusal of these teachers' self-reported survey data shows that they were more like teachers in the fourth quartile on many other behavior and concern variables.

Mr. Day reported using teacher presentation an average of 20% of his class time and small group work 45% of the time. Similarly, Mr. Knight's reported percents were 15 and 35. Both reported using somewhat less teacher presentation than the average 21.5% for both quartiles, but also somewhat less group work than teachers in the first quartile (53.4%). Mr. Day indicated that he supplemented both the CPMP materials and assessments, while Mr. Knight supplemented the assessments only. Also like many other teachers in the fourth quartile, neither used any student presentations or student assessment projects that required a written or oral report. They assigned no extending problems for either at home or in class, and they both gave relatively high grading weights (5% each) to notebooks, journals, and class participation.

Mr. Day and Mr. Knight also expressed more concerns at the end of the year about the CPMP curriculum than was typical of teachers in the first quartile. For example, both were at least somewhat concerned that CPMP requires too many changes, that its impact on low ability students may not be positive, and that students will not be well-prepared for college mathematics. In addition, Mr. Day expressed concern about his ability to manage his students' group work. Some teachers in the first quartile had some of these concerns, but these two teachers' patterns of concerns are closer to what was typical of teachers in the fourth quartile.

Limitations

As in most educational research, students could not be randomized into classes, so we cannot be certain that the relationships we observed can be attributed solely to instructional practices. We tried, in two preceding sections, to eliminate some potential explanatory variables, but this does not eliminate the problem completely. We also cannot say anything about what led teachers to the behaviors that they reported and were observed using. Some may have been trying to please the CPMP team during the field test. We cannot be sure that they would engage in similar behaviors under other, more ordinary, circumstances.

Our use of the ITED-Q as the measure of achievement growth is limiting, although the standard score scale for the alternate forms used for the pretest and posttest was advantageous. Achievement, by definition in this study, was the content of the ITED-Q so it involved conceptual understanding, problem solving, applications and quantitative thinking but did not include algebraic skills. In fact, CPMP's comparative studies (Schoen & Hirsch, In press) suggest that the salient teaching behaviors in this study may not be associated with improvement of algebraic skill, a finding similar to Saxe et al.'s (1999) finding of no association between reform teaching behaviors and computation with fractions.

Finally, our use of questionnaires supplemented by one or two class observations to measure instructional practices does not allow us to capture anything approaching the full richness of what went on in these classrooms. Our data mainly involved estimates of percents or frequency of occurrence of various behaviors. The observation rating, based on one or two classes, was our only estimate of quality of the behaviors. Richer data in the form of more frequent classroom visits, video-taping, and interviews would be useful, but such data are generally too expensive to gather on a scale as large as this study.

Describing the "Effective" CPMP Teacher

In summary, a CPMP teacher whose behavior is positively associated with growth in student achievement would have characteristics and engage in teaching behaviors like the following. This teacher may be of either gender, but we will use female pronouns for convenience. She would either have strong preparation in reform curriculum and teaching before her first CPMP class, or she would have completed a workshop to specifically prepare her to teach the curriculum. That preparation appears to be very important. A year of teaching a pilot version of the same CPMP course does not appear to be a good substitute for a focused professional development experience.

She may teach in a wide variety of urban, suburban or rural school settings. The beginning achievement level of her students may also vary widely. She would most likely be teaching students within her classes who have a wide range of mathematical interests and aptitudes, although that is equally true of teachers in the fourth quartile in this study. She would use the various parts of the CPMP lessons in ways that align well with the developers' expectations. For example, she would use mainly whole class discussion during the launch, spend about two-thirds of her class time on student investigations in which students were mainly working in small groups or pairs, and only spend about 10% of class time working on or reviewing homework.

She would use the CPMP recommendations for homework for the most part, keeping in mind that in each lesson the recommendations involve several choices for teachers and students. She would assign "Extending" problems regularly—about one for homework and one in class per lesson. She would use a variety of assessment techniques including group observations, written and oral reports, and take-home exams. She would also use student journals but typically not for grading purposes. About 50% of her students' grades would be based on in-class exams and quizzes, another 20% on homework, about 10% on group work, and the remainder spread among written and oral reports, notebooks, and attendance/class participation. Each semester or at least each year, she would assign one longer (perhaps a week) group project provided by CPMP.

She would not be likely to supplement the curriculum materials, and if she did it would probably be to add more discovery material. She would also be unlikely to supplement or revise the assessment materials except possibly to combine similar questions or mix forms of a test or quiz. In particular, she would not be inclined to make either the materials or the assessments more structured or skill-oriented. Finally, a trained classroom observer would be likely to rate her class as "Excellent" or Good" in terms of its alignment with CPMP's teaching for understanding model.

By year's end this teacher would have few concerns about the CPMP curriculum. She would feel well informed about the curriculum, its goals and the resources it provides. She would feel confident of her ability to manage her class in group and pair investigations and comfortable with the changes required, including changes in her role as a teacher. Most likely, she would have little concern about the impact that the curriculum has on her students' levels of understanding, algebraic skills and excitement about mathematics. After one year of using CPMP, she would have little concern about trying to improve upon the curriculum.

FINAL NOTES

This study adds to a growing literature that demonstrates a positive association between teaching for understanding and student learning. It supports the findings of others concerning the importance of classroom practices and focused professional development in preparation for their effective use (cf. Stigler & Hiebert, 1999; Weglinsky, 2000) and the importance of complex and challenging tasks and fruitful classroom interactions (cf. Cohen, 1994; Henningsen & Stein, 1997; Hiebert, et al., 1997). This study goes further by linking research on teaching behaviors to the implementation of a curriculum that supports teaching for understanding. A supporting curriculum appears to be a powerful aid to a well-prepared teacher whose goal is to build on her students' thinking and support their sense-making activities. For researchers, the supporting curriculum also has the advantage of providing a common set of instructional materials across teacher subjects.

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